

Final Technical Report

Award Number	G17AP00012
Title of Award	Mapping of the Little Valley Fault, Reno-Carson Nevada
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Abstract.

Maps, photos, and scarp profiles are provided to highlight the geometry and relative age and offset of geomorphic features along the Little Valley fault zone where it strikes northward through and northward from Little Valley. Little Valley is an intermontane valley situated between and in close proximity to the urbanized areas of Reno and Carson City, Nevada. The results of the mapping show the causative fault producing the valley is normal with a significant right-lateral component, that the scarps cut youthful deposits that would be amenable to trenching for paleoseismic information in the future, and the apparent presence of progressively greater vertical offsets on alluvial deposits of respectively increasing age.

Report

Introduction

The Little Valley fault zone extends northward about 20 km from the south end of Little Valley northward along the east flank of Slide Mountain (Figure 1). The northern and southern limits of the fault are located within about 10-15 km to the urbanized regions of Reno and Carson City, respectively. Displacement on the fault zone has produced a small intermontane basin (Little Valley) located just east of the crest of the Northern Carson Range. The fault zone is situated within the Walker Lane, a zone of distributed active faulting that accommodates approximately 8-10 mm/yr of a total 50 mm/yr of relative dextral motion currently taking place

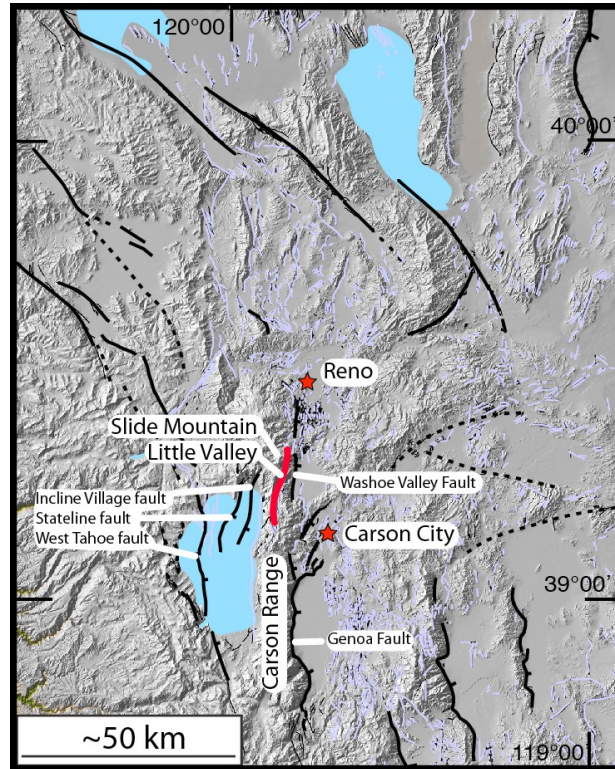


Figure 1. Little Valley fault trace is red. Geographic features mentioned in text are labeled. Major faults the region that have been subject to some prior paleoearthquake or slip rate investigation are bold. Fine blue lines are other Quaternary active faults.

across the Pacific-North America plate boundary (e.g., Hammond and Thatcher, 2007). Nearby active faults include the Washoe Valley fault immediately to the east, the Genoa fault to the southeast, and the Incline Village, North Tahoe/Stateline, and West Tahoe faults to the southwest (Figure 1). The east dipping Genoa and Washoe Valley Faults form the primary range-bounding normal faults of the Carson Range, and both have produced several large Holocene earthquakes (Rood et al., 2012). There is thus reason to consider that the fault within Little Valley accommodates a portion Walker Lane slip and is capable of producing moderate to large earthquakes capable of producing significant damage in the Carson and Reno

areas.

The purpose of this small project was to move towards gathering information bearing on the slip rate and paleoseismic history of the Little Valley fault that may ultimately be incorporated into the National Seismic Hazard maps and motivate hazard mitigation efforts in the urban areas of Reno and Carson City. The recent existence of lidar in the area provides a basis to more accurately identify and locate traces of the Little Valley fault. With lidar and field reconnaissance, we conducted mapping to give context to the fault trace in relationship to the Quaternary deposits it displaces and geomorphic features it creates and consider whether or not there exist sites amenable to determining the slip rate and paleoseismic history of the fault. This report describes the results of this effort with maps, photos, and scarp profiles that highlight the geometry and relative age and offset of geomorphic features along the Little Valley fault zone.

Quaternary Deposits and Fault Offsets in Little Valley

Displacement on the Little Valley Fault zone is responsible for the development of Little Valley which encompasses approximately the southern one-half of the Little Valley fault zone. The fault cuts young sedimentary deposits and geomorphic surfaces in Little Valley and it is for this reason we here focused field efforts. Northward of Little Valley, the fault trace is generally located in very rugged and steep topography and access limited because of land ownership issues. The physiography of Little Valley is illustrated as a shaded relief map in **Figure 2a**. Quaternary deposits and active fault traces observed within Little Valley are shown on the same physiographic base map and a topographic map base in **Figure 2b**. The maps show the west side of the basin to be cut by a system of east-dipping faults with normal displacement. Two distinct scarps of west-dipping faults are also present on the east side of the basin. Taken together, the pattern of fault traces defines a generally left-stepping en echelon pattern. The pattern is interpreted to suggest normal displacements on these faults are also accompanied by a right-lateral component of slip and that the basin is the result of transtensional deformation rather than pure dip-slip. The linear ridge or horst along the trace in the northernmost portion of the map area may also be a result of strike-slip deformation. No obvious lateral offsets of landforms (gullies, ridges, terrace risers, etc) in the Valley were observed in imagery or in the field to confirm the assessment of strike-slip displacement.

The east-dipping range-bounding fault along the west flank of the basin appears largely responsible for development of the graben that is Little

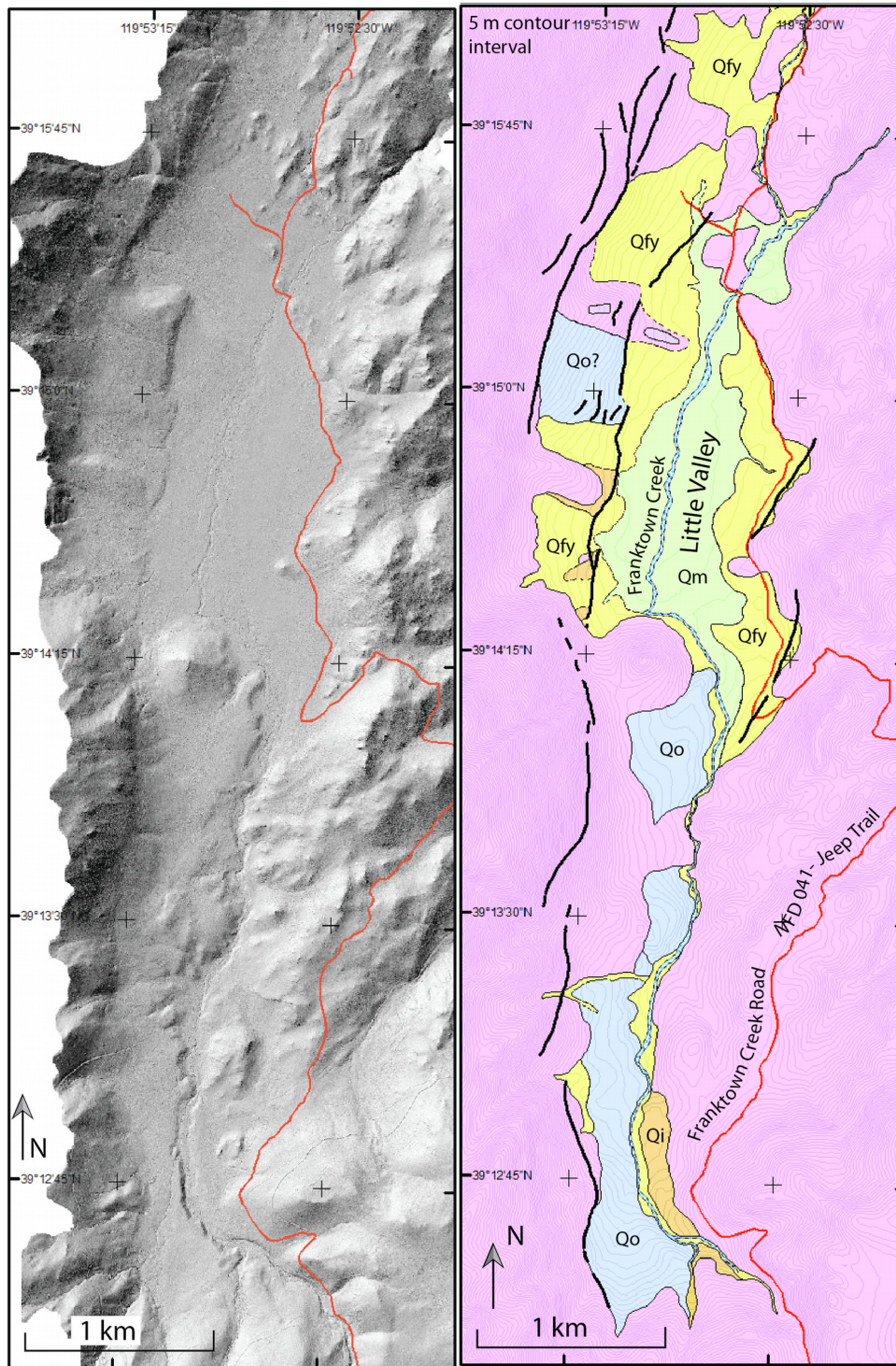


Figure 2. (A, left) Physiographic (shaded relief) map of Little Valley constructed from Lidar data acquired by National Center for Airborne Laser Mapping (NCALM) with funding from NSF's Division of Earth Sciences, Instrumentation and Facilities Program (EAR-1043051). (B, right) Active fault traces (black lines) in relation to Quaternary deposits and surfaces (see text unit descriptions) and 5 m contour map.

Valley. The majority of the east-dipping trace cuts across steep slopes generally devoid of any significant amount of late Pleistocene deposits. Fault traces are observed to cut deposits and geomorphic surfaces considered to be late Pleistocene – Holocene age within Little Valley. The Quaternary deposits of the valley are, in addition to the marsh and meadowlands that fill the central valley along Franktown Creek (unit Qm), divided into 3 units of relatively increasing age. The relative age determinations are based primarily on geomorphic position, with the older deposits forming surfaces preserved higher than younger. In this regard, Qfy, Qi and Qo are progressively older Quaternary surfaces. Repeated late Pleistocene movement of the fault system is manifest by the relatively greater fault scarp heights that respectively truncate the relatively older surfaces. The pink areas are undifferentiated bedrock, generally granite of the Carson Range.

Scarp Profiles, Photos, and Potential Sites for Paleoseismic Investigation.

Topographic profiles across traces of the Little Valley fault are constructed for the sites indexed in **Figure 3**. Each of the profiles is shown in **Figure 4**. The profiles serve to illustrate the size and character of fault scarps within the Valley and the progressively greater offset of the fault across older geomorphic surfaces. Additionally, ground photos of the fault scarps at and near the location of the profiles are provided in **Figures 5**. The photos serve to further document the morphology and vegetation at and in the vicinity of the scarp profiles.

In southernmost Little Valley, the fault trace divides bedrock from older Qo deposits (**Figures 2 and 3**). The fault trace is locally manifest in the colluvial apron and fan deposits of size insufficient to delineate at the scale of mapping

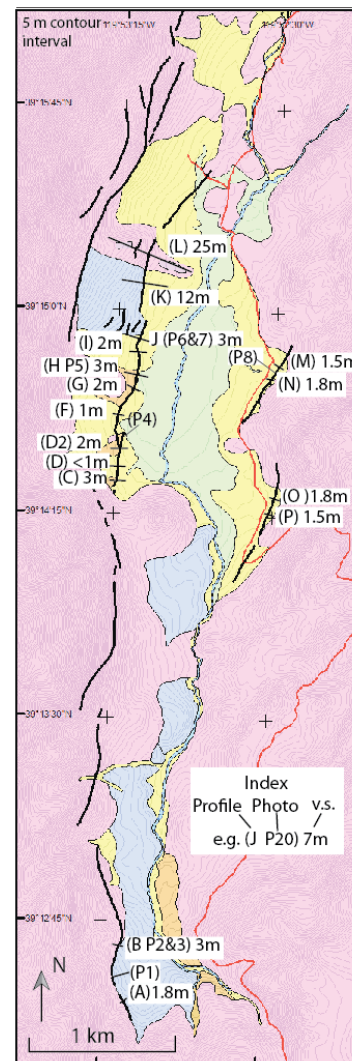


Figure 3. (right) Index map to location of scarp profiles and photos shown in Figures 4 and 5, respectively, that serve to quantify size and character of offsets and morphology of fault scarps.

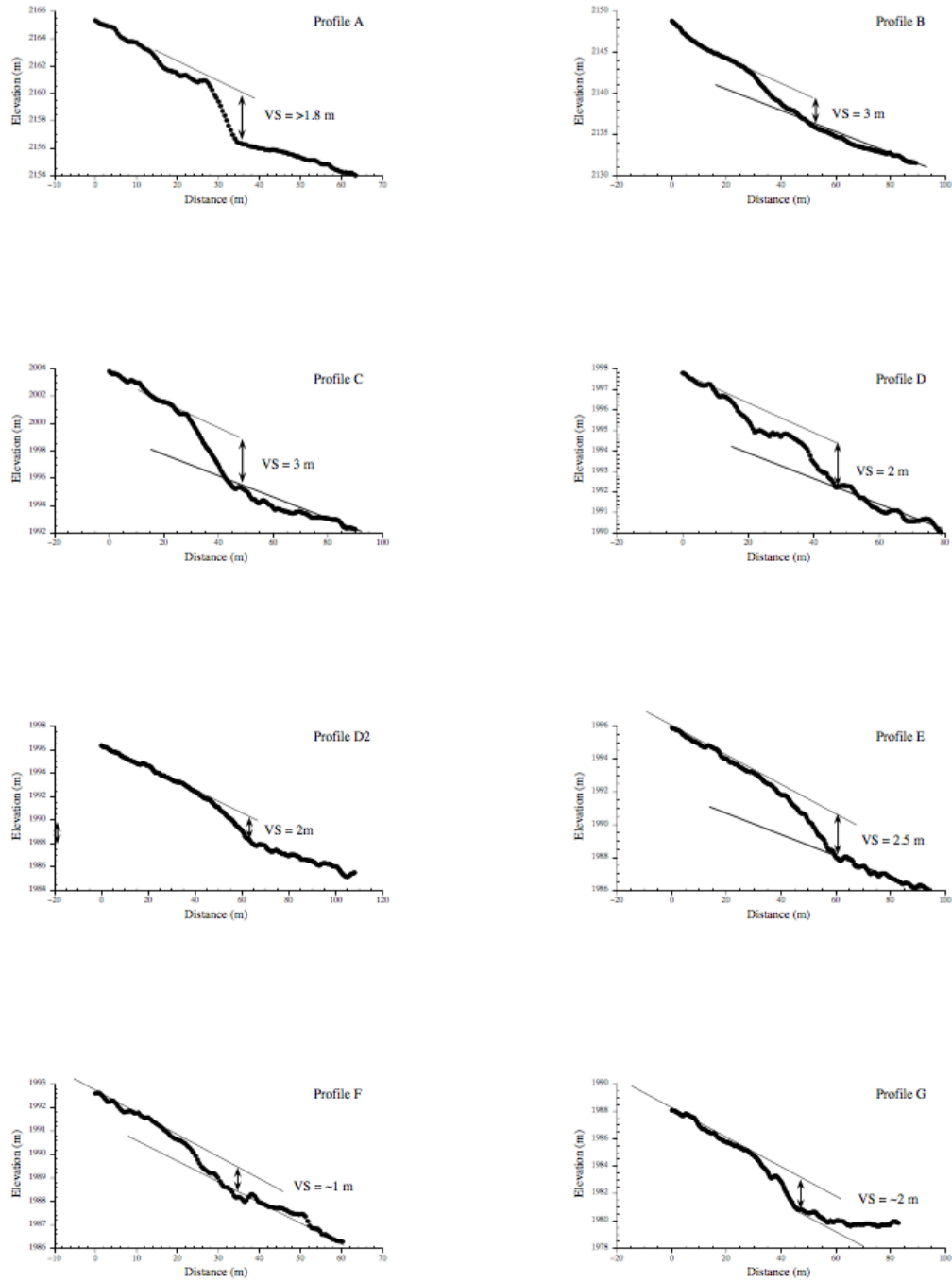


Figure 4. Scarp profiles constructed along transects A through G for which locations are shown in Figure 3.

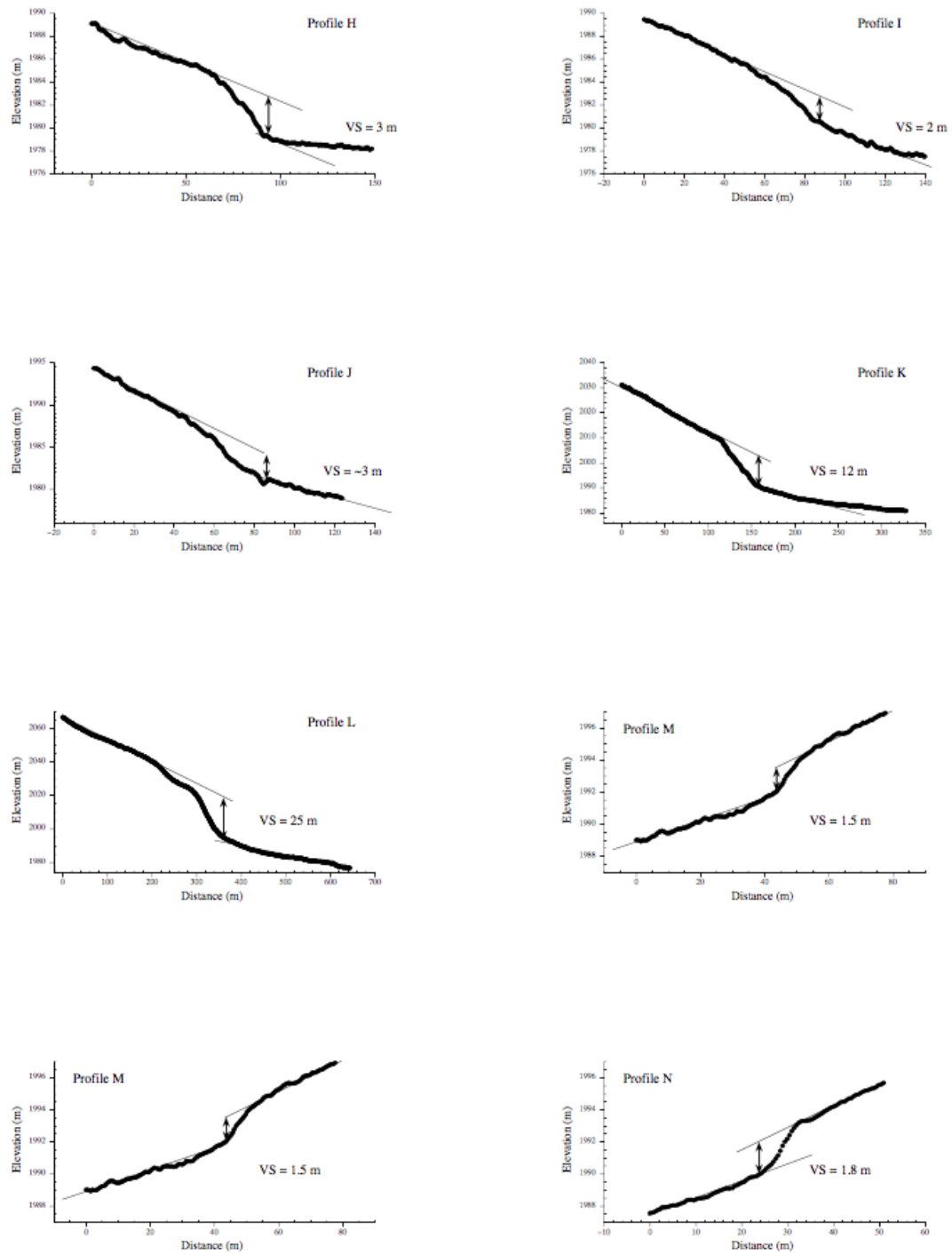


Figure 4 continued. Scarp profiles constructed along transects H through N for which locations are shown in Figure 3.

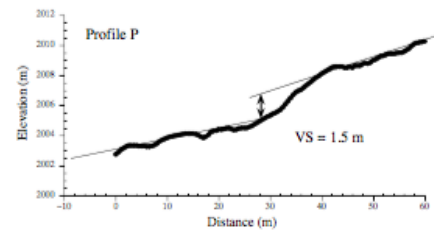
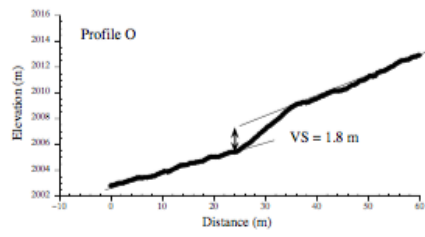


Figure 4 continued. Scarp profiles constructed along transects O through P for which locations are shown in Figure 3.

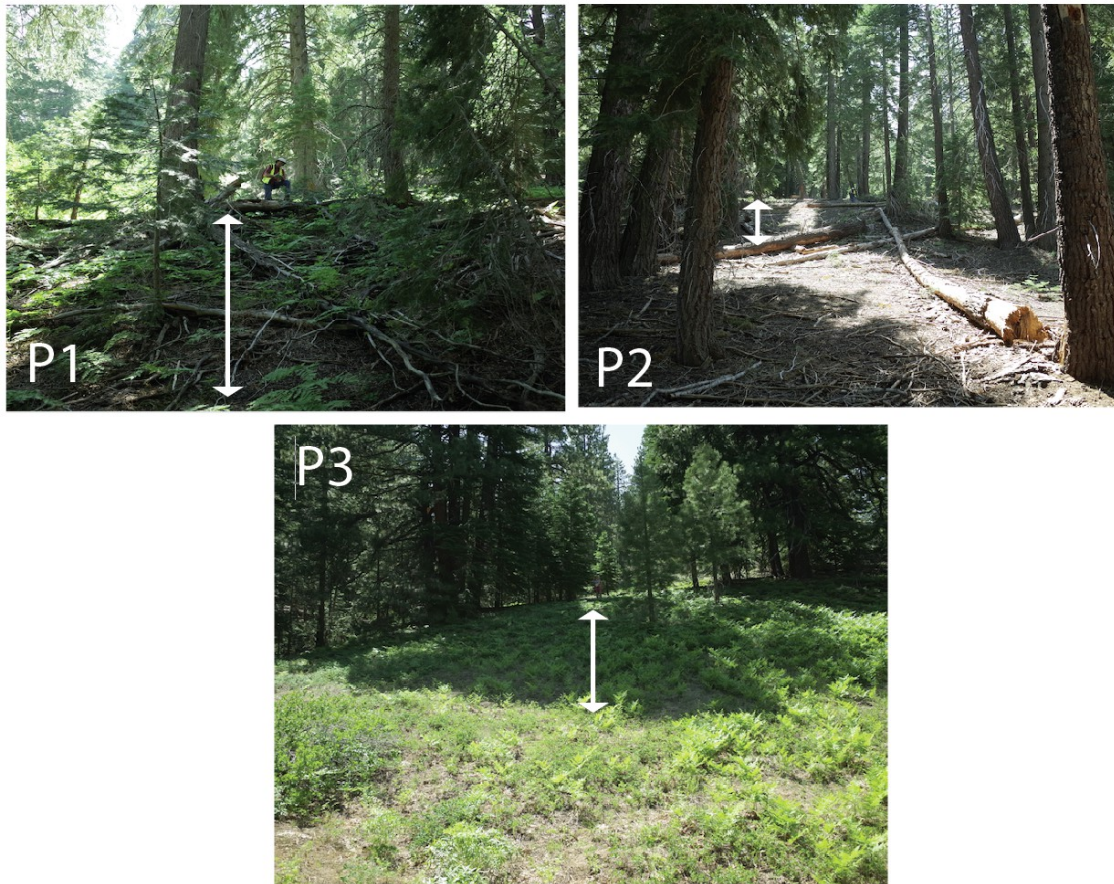


Figure 5a. Photos of scarps toward south end of Little Valley. (upper left) Scarp between profiles A and B. (upper right) Scarp at profile B. (lower) Scarp immediately north of Profile B. Arrowheads placed at scarp base and scarp crest. Locations of photos indexed in Figure 3. The observed scarp heights range from 2 to 3m. Waypoints for P1 and P2 are 39.209407° -119.886587° , 39.210830° -119.886240° , and P3 just across small drainage from P2.

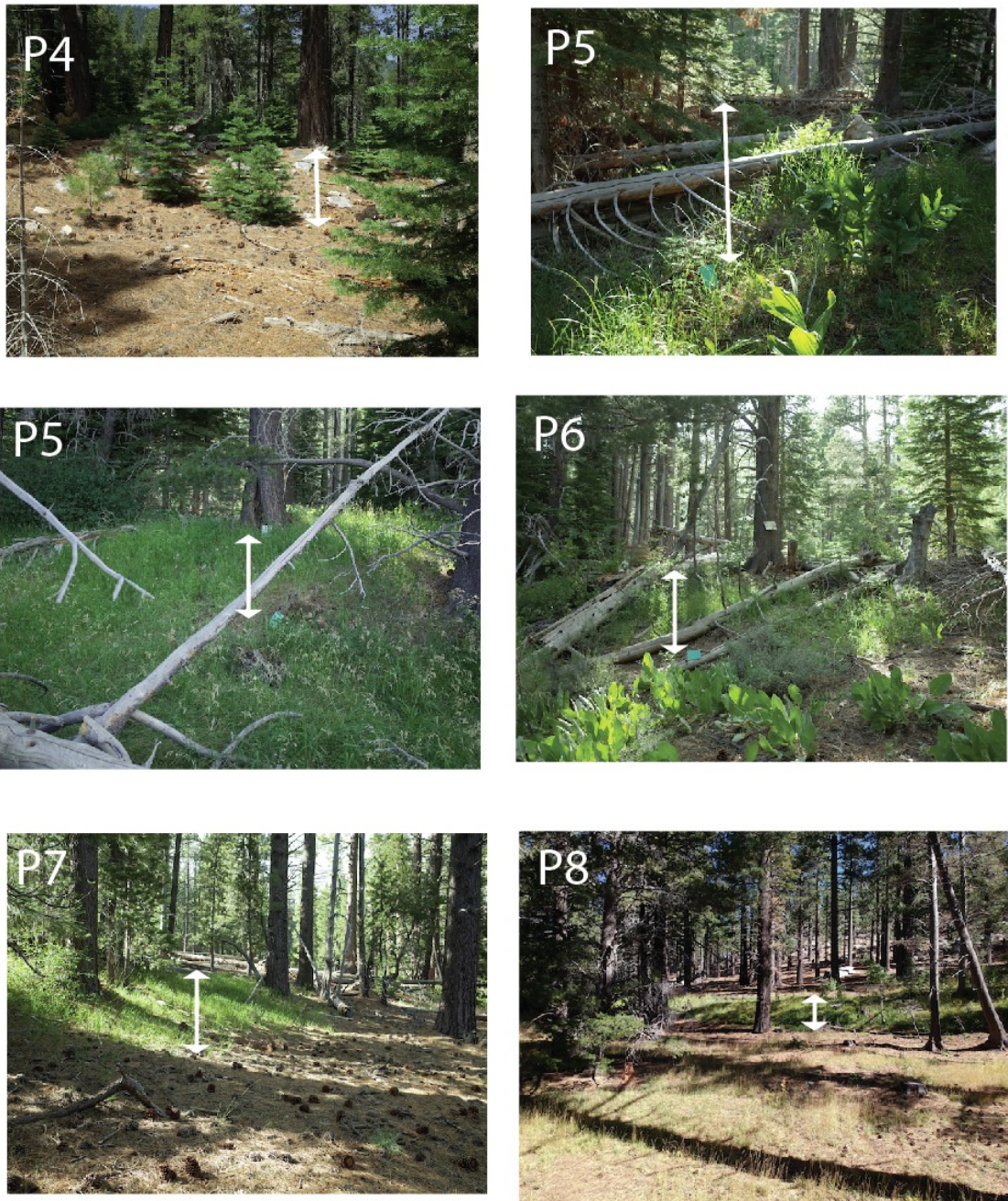


Figure 5b. Photos of scarps within main portion of Little Valley. Index of the location of each photo is in Figure 3. See text for discussion of photos in context to location of map units and scarp profiles in Figure 5. The locations of the photos are: P4, 39.242438° -119.886876°; P5, 39.245780° -119.885850°; P6, 39.248056° -119.886082°; P7, 39.248282° -119.885789°; P8, near 39.246362° -119.875810°.

in **Figure 2 and 3**. Generally heavily forested in this region, vertical separations measured with topographic profiles constructed across the alluvial scarps are in the range of about 1.8 to 3 m (**Profiles A and B in Figure 3**). Photos **P1**, **P2**, and **P3** of scarps between **profiles A and B**, at **Profile B**, and ~15 m north of **Profile B**, respectively, are shown in **Figure 5a**. Northward, at the southern end of the main valley, topographic **profiles C, D, and D2** show vertical separations across the fault trace of 3, <1, and 2 m, respectively (**Figures 2, 3, and 4**). The relatively larger displacement observed in the vicinity of **profiles C and D2** in comparison to near **D** provided reason to delineate Oy from Qi deposits in this area (**Figure 3**). Given the interpretation is correct, it is implied that the scarps abutting the Qy surfaces record offset from more than one earthquake. **Photo P4 in Figure 5b** illustrates the broad nature of the fault scarp truncating the Qi surface.

Yet further northward, **profiles F, G, H and I** are located across the fault trace where it cuts Qy and Qi surfaces (**Figures 2 and 3**). Vertical separations across the fault range from 1 to 3 m, with larger displacements tending to register in the surface mapped to be Qi. The correlation of lesser to relatively greater scarp height between the Qy and Qi fault scarps is not perfect and so there is some uncertainty in the interpretation that the mapped units record different number of earthquakes. Because of the stepping nature of the fault zone and the extensive vegetation, further investigation would be needed to completely rule out that variations in scarp height here don't simply reflect variations in scarp height that might occur in a given earthquake. **Photos P5 in Figure 5b** further illustrates the character of scarp in the Qy surface at **profile H**. The scarp when observed in the field appears compound with subparallel scarps over a relatively broad width of ~10 m.

Profile J is located where the fault cuts a small element of deposit interpreted to be Qy which is nested on the south edge of a significantly higher Qo alluvial-pediment surface (**Figures 2 and 3**). The profile J records ~3 m of vertical separation in comparison to 12 m (**Profile K**) across the **Qo** surface. The profiles illustrate the clearest example of progressive and continuous offset across the fault during latest Pleistocene. **Photos P6 and P7 in Figure 5b** are at the location of **Profile J**. The well defined scarp here would be amenable to trenching for a paleoseismic investigation.

The longer term offset of the Little Valley scarp is yet further illustrated by the **Profile L (Figure 3)** which registers largest observed scarp height of 25 meters on this trace of the fault zone (**Figures 3 and 4**). The profile is placed across what is mapped as undifferentiated rocks. On either side of the fault scarp here are elements of relatively flat surfaces (pediment?)

covered with similarly large granitic boulders. One may speculate that use of cosmogenic dating methods on the boulders might define the age of the surfaces and thus provide a basis for a longer-term slip rate. The site deserves further examination to assess the validity of such an approach at this site.

Shifting attention across the valley, there exist two distinct west-dipping en-echelon fault traces for which **Profiles M through P** illustrate displacement has produced vertical separation on the range of 1 -2 m (**Figures 3 and 4**). **Photo P8** in **Figure 5b** is characteristic of the form of the two fault traces along much of their lengths. The scarps are simple in form and of a size amenable to a paleoseismic trenching investigations.

Strike-slip offset along Little Valley fault zone

Direct evidence of strike-slip offset was not observed in this study of Little Valley fault within Little Valley proper, though the presence of right-lateral strike slip is certainly suggested by the left-stepping nature of the fault traces observed within Little Valley (**Figure 2**). A clear direct suggestion of right-lateral displacement is observed north of Little Valley where the fault trace continues northward through rugged mountainous topography cuts across the base of Slide Mountain (**Figure 1**). Here, the trace displaces several large gulleys on the very steep mountain face directly below the access road to the Slide Mountain ski area (**Figure 7**).



Figure 7. Aerial view west toward flank of Slide Mountain and below access road to Slide Side of Mt. Rose ski area shows apparent vertical and right-lateral offset of drainages that are cut by the Little Valley fault scarp that trends from left (south) to right (north) across the lower-center of the photo.

Summary and Conclusion

The goal of this small effort was to enter Little Valley, accurately document the location of fault traces, and assess the possibility of conducting a paleoearthquake investigation to ascertain the size and frequency at which earthquakes have occurred and thus expected to again occur in the future. Toward that end, we used field examination in conjunction with Lidar to construct a preliminary surficial geologic map showing the interaction of the Little Valley fault with alluvial deposits and surfaces and additionally made scarp profiles to illustrate the relative size of displacements that the fault trace exhibits along Quaternary surfaces of progressively greater age. In sum, it is concluded that the geology or, more specifically, the interaction of the Little Valley fault trace with Quaternary deposits makes it most amenable for a paleoearthquake trenching investigation. Such a study holds the potential to define the past size and recurrence rate of large earthquakes along the Little Valley fault. This type of information is that needed to increase the accuracy of the USGS national hazard maps in this area and provide further knowledge to support and guide earthquake hazard mitigation efforts in the rapidly urbanizing areas of Reno and Carson City. Specific sites that appear most amenable for such a study from our reconnaissance include the site of Profile J (**Figure 4 and Photo P7 in Figure 5b**) and the site of **Profiles M and N** on the west side of the valley (**Figure 4 and Photo P8 in Figure 5b**). The larger scarp documented in Photo P7 appears most likely to record multiple offsets and thus may provide information on event displacement-size, timing and recurrence. The smaller scarp at **P8** appears to be the result of a single event though may as well hold evidence of yet older events in the subsurface. Together, the sites it hold the potential to place bounds on the timing and displacement of the most recent displacement.

References.

- Hammond, W.C., Thatcher, W., 2007. Crustal deformation across the Sierra Nevada, northern Walker Lane, Basin and Range transition, western United States measured with GPS, 2000-2004. *J Geophys Res-Sol Ea* 112, 26.
- Rood, D.H., Ramelli, A.R., Harvey, J., Burbank, D.W., Bookhagen, B., 2012. F.O.P. 2012 Guidebook - Sept 13-16 - Neotectonics of the Lake Tahoe and Carson and Sierra Valleys - Day 1 - Stop 1, in: Seitz, G., Ramelli, A.R., Seitz, G., Kent, G.M., Smith, S., Hammond, W., Leaders), T. (Eds.), F.O.P. 2012 Guidebook - Sept 13-16 - Neotectonics of the Lake Tahoe and Carson and Sierra Valleys, p. p. 35.

Note: No additional professional journal papers have resulted from this research. No funds were requested for such publication in the original proposal.